Warming to the Fight

Multiscale effects are challenging issues in materials science, but ours is not the only domain in which they are of current interest. Global climate change obviously operates at the largest length-scales available on a planet the size of Earth (or even Saturn, where the famous red spot is shrinking) but it is a product of effects that operate on the scales of individual machines, buildings, cities, tidal systems, and the molecular reactions within each of these. Understanding all of these is a daunting task.

Atmospheric carbon dioxide has become the primary focus of much of the attention, now championed in the United States by President Obama's chief science advisor, John Holdren. At 385 ppm, the CO_2 concentration is the highest it has been in the current epoch, and its concentration seems to correlate with mean global surface temperature, which all makes great sense in a simple way, when you recognize that CO_2 is a "greenhouse gas."

Holdren is pushing hard for a set of initiatives that would slow the increase in the CO_2 concentration, and eventually stabilize or even reduce it. The implication is that this would control global warming. That is where it gets controversial. The arguments boil down to two broad categories: There are some who believe that global warming is a change that we should embrace rather than resist; and there are others who assert that we cannot affect it through control of atmospheric CO_2.

It is only human nature to resist change, but it is also the genius of the human race to be able to adapt to it. Since the emergence of the first humans there have been many changes in the global climate and we are still here, even though the world is quite a different place than it has been. At the time of the first humans the Sahara was a vast savannah rather than a desert, and much more recently Europe has lived through "little ice ages" between AD 1150 and 1460, and from 1560 to 1850. Of course the human race had less infrastructure in those times, and was therefore much more able to adapt. With larger fractions of the population living near coastlines, it is getting harder and harder to adapt to things like rising sea levels and more extreme storm systems. Ask the residents of the Maldives or New Orleans. In the words of U.S. Secretary of Energy, Steven Chu, "If only half of the predicted effects are only half as bad as predicted, we have to do something about this."

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Then there is the question of what we can do. Nobody who has looked at the data can deny that there is a correlation between atmospheric CO_2 concentration and mean surface temperature, but there are many difficult questions about how this multiscale, multicomponent system really works, and whether we can stop or even slow global warming by controlling the CO_2 level. Leaving aside the question of what it costs to reduce CO_2 levels, there are still concerns about the predictions of our complex climate models as to the outcomes of such actions. Experimentation is the gold standard of science, and the standard of proof that we materials scientists live by is the use of control experiments to isolate the effects of all of the variables. We do not have the luxury of a spare planet on which to conduct control experiments about global warming, so we are left with a dilemma.


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Should we commit our resources to mitigating the warming, through controlling greenhouse gases, or should we use our assets to prepare for its effects?

It is a real choice because of the materials involved.

The impact of global warming will be felt in many ways, but two, in particular, have a direct effect on humankind. These are rising sea levels, and redistribution of fresh water resources. Adapting to these would call for large-scale infrastructure projects that rely primarily on a single material—concrete. And concrete production is a leading source of atmospheric carbon dioxide. If we fight the effects of global warming, we will contribute to its causes, according to the present models. Now here is a truly great "grand challenge" for materials science: provide an alternative to concrete that does not generate CO_2; or perhaps come up with a way to sequester all of the CO_2 from concrete production. Either way, it had better be cheap, and it had better have no serious environmental impacts.

It has been about 50 years since science has been so firmly in the driver's seat for the future of humankind. It is worth remembering that trust and credibility are essential to maintaining the kinds of leadership that are needed, and that those intangible commodities are more easily squandered than energy itself. Beware of promises, actual or implied, like those of U.S. Surgeon General William H. Stewart who was so enthused with the success of antibiotics and vaccination programs that he declared in the late 1960s that it was time to close the book on infectious diseases. Remember, too, the promise by Lewis Strauss in 1954, then chair of the U.S. Atomic Energy Commission, that electricity would eventually be "too cheap to meter." Both of these distinguished government science advisors were foiled by systems and other external influences that were much more complex than their initial understanding of them. If we scientists do not fool ourselves about the big issues of today, perhaps we will not end up with the public accusing us of fooling them, yet again.

Alex King

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